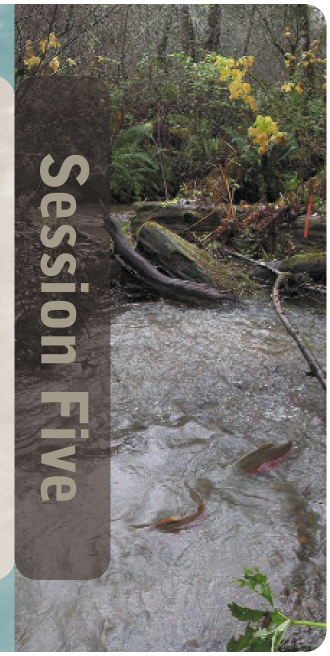
Upgrading and installation of fish passages and fish screens, offstream water storage

Oregon Department of Fish and Wildlife Fish Screening Program: Fish Screen Types and Costs



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ABSTRACT

The Oregon Department of Fish and Wildlife (ODFW) has been directly involved in the development, modification, and placement of fish screens for many years. This paper presents an overview of the major types of fish screens currently in use and a discussion of the average costs for fish screens in the State of Oregon.

INTRODUCTION

As the photograph in Figure 1 demonstrates, vast numbers of fish are killed each year in ditches where they have been stranded after passing through unscreened diversions. To address this problem, the State of Oregon has implemented a cost-share program that gives farmers incentives to screen their diversions. ODFW provides expertise and years of experience, ensuring that the projects are functional and cost-efficient.

Figure 1. Fish kill in unscreened part of diversion (fish in ditch between diversion point and screen, eastern Washington)

Table 1. ODFW Fish Screening Program, average fish screen costs

Fish screen type	N	Flow rate (cfs)	Cost ($)	Cost/cfs ($)
Rotary drum	12	0.4 – 25.0	4,500 – 45,000	1,309 – 11,250
Rotary drum, prefab (all 18″d drums)	4	0.8 – 2.0	7,392 – 7,834	3,859 – 9,358
Belt	3	10.0	23,135 – 31,608	2,313 – 3,161
Panel	2	12.0 – 30.0	36,926 – 85,000	2,833 – 3,077
Pump, low velocity	10	0.5 – 1.8	801 – 1,662	801 – 1,915
Pump, Clemons	10	0.6 – 4.2	1,000 – 3,441	520 – 2,220
Pump, Sure Flo	10	0.5 – 6.0	1,029 – 2,856	476 – 2,450
All fish screens are self-cleaning except for the low velocity pump screen				

Table 1 presents a comparison of the different screen types in use today, the flow rates (cubic feet per second, CFS) that they are designed for, their total cost ranges and their costs per CFS. This table will be used as a reference in the discussion that follows.

FISH SCREEN TYPES

Box Screens

The science and engineering behind fish screening has progressed considerably over the years. One of the earliest fish screens deployed in Oregon was called the Iron Maiden. At that time, keeping project costs low was the highest priority, so the Iron Maiden is simply an iron box weighing about 600 pounds with a 1/8-inch perforated plate screen. While it did not cost much, it was far too heavy for safe and effective installation.

After the Iron Maiden, we developed an aluminum version of the box screen. These were light, but screens had to be manually cleaned.

Figure 2 shows a box screen, which will handle 5 CFS and costs $1,000 per CFS. The screen has a brush system with a paddle. We can easily lift this screen, place it in a truck and put it in a ditch.

Figure 2. Paddle box screen (screen at ditch diversion point in Jack Creek, eastern Oregon; stream powers paddle; brush on one paddle cleans screen; 1 cfs)

Rotary Drum Screens (Custom and Pre-fabricated)

Table 1 shows that for about a dozen sample rotary drum screens, the flow rates ranged from 0.4 to 25 CFS, with the 25 CFS model costing $45,000. It is important to note that for a larger scale project, the cost per CFS will tend to be smaller than for smaller screens. The rotary drum screen in Figure 3 was built in the ODFW shop in John Day, Oregon. Very little engineering is required to construct these screens, which helps to keep the screen costs low. At our screen shop, we have forms for the screens that can be used for most of the diversions in the John Day Basin because the diversions are all very similar — fairly flat with some fall to them.

Figure 3. Rotary drum screen (self-cleaning single drum screen; paddle powered; one-bay; John Day River Basin, eastern Oregon)

Generally we install small screens as in Figure 3, which cost $4,000–$5,000 per CFS. The screens are powered by paddle wheels because there is often no available electricity. Water enters the structure, turns the paddle wheel, gets reversed through a couple of gearboxes, and then goes to the drum. The drums all turn in the same direction and are very well sealed. The fish enter a bypass that carries them safely back to the stream.

Sealing the drum screens is very important. The drums we use now are wrapped with perforated stainless steel plates with 3/32-inch diameter holes. The drums have both side and bottom seals. The seal integrity is very important. Work at Battelle Seattle Research Center has shown that salmonid fry can fit easily through a 3/32-inch opening.

Drum screens can be distinguished by the number of bays. Figure 3 shows a one-bay screen; we also have examples of two-, three- and four-bay screens. Figure 4 shows a four-bay drum screen. The reason for the different numbers of bays is related to the flow rate; streams with highly variable flows are more efficiently served by screens with multiple bays. Ditches are usually watered up in the first few days of spring. Often the screen flow can exceed the maximum that one screen can handle, necessitating multiple screens. When the stream flow drops in August and September, though, bays can be shut off, leaving only one or two drum screens working.

Figure 4. Rotary drum screen (self-cleaning drum screen; paddle powered; four-bay; Rogue River Basin, southwestern Oregon; 29 cfs)

The four-bay screen in Figure 4 is for flows up to 25 CFS and costs $45,000 to construct. This was a joint project, with an ODFW crew doing most of the concrete and metal work. Trout Unlimited paid for some of the costs, and some labor and equipment (dump trucks) were donated.

Figure 5 is an example of an electric-powered rotary drum screen. We use these screens only rarely and so do not maintain a list of prices. The screens have small electric

Figure 5. Rotary drum screen (self-cleaning drum screen; electric powered; eastern Washington)

motors turning the drums. Water flows along the screen faces into the bypass. Electric-powered drum screens can be very large, as shown in Figure 6.

Figure 6. Rotary drum screen (large drum screen, 19´ in diameter; Red Bluff, California)

Table 1 shows some figures for rotary drum pre-fabricated screens (18-inch diameter), which are a bit costly. The cost for flow rates of between 0.8 to 2.0 CFS runs $4,000 –$9,000/CFS installed. However, the high costs are more than compensated for by the savings if a farmer wants to move his entire water right to another ditch. A pre-fabricated screen can be easily removed from one ditch and placed in another with only minor modifications needed.

Belt Screens

We have a few belt screens installed in Oregon. Figure 7 shows an example in Washington, and Figure 8 an Oregon example. Belt screens are self-cleaning, with the belt moving in an endless loop powered by electricity. As the water goes through the stream, the debris is carried down the ditch. Belt screens tend to be expensive. The screen in Figure 7 handles about 10 CFS. It is lifted in the winter, but is normally down behind

Figure 7. Traveling belt screen (eastern Washington)

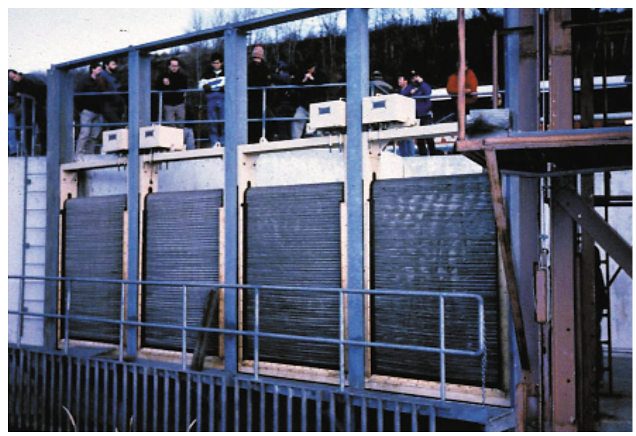


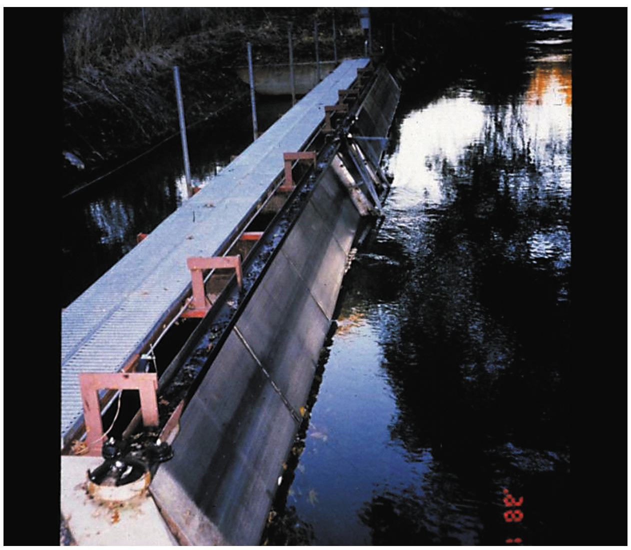
Figure 8. Traveling belt screen (plastic; 10 cfs solar powered screen; eastern Oregon)

the trash rack in the stream. The screen in Figure 8 is a plastic panel system that costs about $3,000 per CFS. It has a solar battery.

Panel Screens

Panel screens with self-cleaning brush systems are used in California (Figure 9) and Washington. These screens accommodate water depth changes more effectively than rotary drum screens.

Figure 9. Self-cleaning panel screen (160 cfs wiper brush self-cleaning screen; electric powered; Parrot-Phelan Diversion in northern California)



Pump Screens — Low Velocity

There are three major types of pump screens. Figure 10 shows the first type, a passive screen (low-velocity). The pump is up on the bank, and the suction end in the stream. The screen mesh is 3/32 inch to meet National Marine Fisheries Service (NMFS) screening criteria. A shear flow is required in addition to sweeping velocity in order for the screen to work. Usually the sweeping velocity in the vicinity of the screen is a lot higher than the approach velocity of 0.4 feet per second. There is so much surface area that leaves and other debris tumble when they go downstream instead of hanging up on the

Figure 10. Low velocity pump screen (Pump-Rite manually-cleaned pump screen; water velocity balance tube inside)

screen. The screens tend to maintain themselves fairly well if there is a good sweeping flow. I know farmers who do not clean this type of screen for an entire irrigation season without losing any of the functionality of the screen. The frequency with which the screens must be cleaned depends on location and debris load in the stream, including algae.

A man in Junction City, Oregon invented the screen shown in Figure 10. It is inexpensive and it has no moving parts, so the cost per CFS is low. The screen can handle about 1 CFS.

Pump Screens — Clemons

The Clemons self-cleaning pump screen has cleaning arms that spin inside the stationary screen and blow debris off the mesh. The screen in Figure 11 has 10 meshes to the inch, which exceeds NMFS screening standards. The unit is very heavy, so it stays in place. Clemons screens cost $520–$2200 per CFS and can handle up to about 4 CFS.

At installation, we tell the farmers to place a construction block underneath the screen to keep it above any stream debris or fine silt that might disrupt the screen. Generally, when these are installed in the streams in March or April, most of the heavy flows are over, so the screen will not get silted in. Generally, irrigation season in

Figure 11. Clemons pump screen (self-cleaning pump screen)

Oregon begins in March or early April, depending on spring rainfall, and runs until the middle or end of October. Once irrigation is finished, we remove all of the screens and replace them again in the spring.

Pump Screens — Sure Flo

Figure 12 shows a mainstay of self-cleaning screens: the Sure-Flo self-cleaning pump screen. Refer to Table 1 for the cost range for this type of screen. This screen has jets inside that spin the screen and clean the debris. The Sure-Flo screen also has a balance tube inside to ensure the approach velocity is uniform. There are probably 200 of these screens currently installed in Oregon, and they have proven successful. The larger unit shown in Figure 12 operates at about 2.7 CFS, but Sure-Flos can be bought off the shelf that will handle about 5.5 CFS.

Figure 12. Sure-Flo pump screen (self-cleaning pump screen; water velocity balance tube inside)

FISH SCREEN BYPASSES

In any discussion of fish screens, bypasses will be mentioned frequently. A bypass takes the fish that have been prevented from entering the diversion by the screen and delivers them safely back into the stream (Figure 13). Bypasses must be carefully monitored because every year the stream may shift during a winter storm. This means that suddenly the bypass no longer empties into the stream but instead dumps the fish out onto rocks.

Figure 13. Fish screen bypass (bypass safely returns screened fish to stream; bypass can be very long, even hundreds of feet; eastern Oregon)

Bypasses are a very important tool for us to measure the success of the screens. On some of the bypasses on drum screens in the Rogue River Basin and the John Day Basin, just before the bypass goes into the

Figure 14. Screen bypass trap box (fish saved by screen are sorted by species and counted; steelhead smolts in box in photo; John Day River Basin, eastern Oregon)

river, we construct a concrete box (Figure 14). Then we periodically put another screen into the box and, as the bypass water from the stream comes into the box, we trap whatever fish are in there. We can then ascertain fish species and obtain an estimate of the numbers of fish that are being saved by the screen.

SCREEN INVENTORY

An attempt at an inventory of Oregon diversions was made about 10 years ago. At that point, if our biologists knew of a diversion, they told us about it. However, many diversions were unknown. So we went to the Water Resources Department and obtained the Oregon Water Rights Information System database, which lists all the permits and certificates for water rights held in the State of Oregon. Unfortunately, the names were those of the *original* landowners, as far back as the middle 1800s!

We hope to access federal money that President Clinton signed into law from the Irrigation Mitigation Act of 2000 (PL106-502), which will make available to the States of Oregon, Washington, Idaho, and Montana $25 million per year over a five-year period for screening and passage at diversions. The State of Oregon hopes to get some of this money for a complete inventory to find the still un-catalogued diversions.

Our current estimate is that there are more than 55,000 unscreened diversions in Oregon, and at least the top 3,000–3,500 need to be screened to save listed species.

The best data that we have for Oregon is for the Columbia River. We know every diversion on the Oregon side of the Columbia River. We have also done a comprehensive survey on the Willamette River. Water Resources personnel, Oregon State Police and staff from ODFW went in boats up and down the river from Eugene to the mouth of the Willamette looking for diversions. They found about 510. Water Resources staff are now identifying who owns them. This process will also identify problems with the water rights. For example, it didn't take long to realize that some of those diversions on the Willamette were illegal.

FISH SCREEN COSTS

The easiest screens to accurately predict costs for are pump screens. Their installation is privately contracted and uses off-the-shelf technology, which means that costs will fall within a well-defined range. The costs for pump screens generally tend to be lower than for ditch screens. In addition, pump screens are an easy sell to the farmers, because they also keep snails and debris out of rainbird sprinklers. When farmers see a little 3/32-inch mesh screen that will keep the snails out and the State offers them a 60% cost-share program, they love it.

Building Our Own Screens

One cost-reducing measure that has developed in Oregon is that unless rotary drum screens are over 25 CFS, we no longer need to incur engineering expenses. We have enough cumulative experience to have an existing design. And because our shop staff builds the screens, the costs stay much lower than if we contracted out the engineering and construction. Our screen shop has sets of forms for any drum screen size that is currently used in the State of Oregon up to 25 CFS. All that is needed to design a screen for a new diversion is a quick and inexpensive survey of the ditch. The surveyor can measure the ditch and develop a plan immediately based on our standard designs.

Most of our screen costs are for materials, construction and installation labor. The ratio of labor costs to material costs on drum screens is 70:30. We have a useful manual from the John Day screen shop that contains all the costs for building screens, including component costs and supplies for every kind of screen (pre-fabricated and otherwise). The costs are broken out by channel, perf-plate, flat-bars, rubber seals, form costs, reinforcing steel and concrete. Another table in the manual gives the necessary screen dimensions for different levels of stream flow. For example, if the diversion is 3 CFS, the table lists the screen diameter that will be needed to handle that flow.

The one thing we cannot know until we complete a project is how much bypass pipe is required. We also cannot know how much travel and hotel time will be required for installation crews (pouring the concrete and putting in the steel). However, the John Day shop cost manual includes cost for per diem and mileage, so we can make an initial estimate when we are planning a new project.

FISH SCREENING ORGANIZATION

The ODFW coordinates fish screening installations throughout the state, with a statewide coordinator and three field coordinators who handle southwest Oregon, the Willamette Valley/Deschutes, and eastern Oregon. We work with 95 watershed councils throughout the State. The watershed councils then work directly with farmers to interest them in screening their diversions. Our cost-share program is voluntary and done when a farmer expresses interest. We do not force farmers to screen any diversions under 30 CFS.

The state has a very good working relationship with the water-user community, including large irrigation districts that generally have screen flows over 30 CFS, and smaller farmers. Many of the ditches we screen are only 1 to 5 CFS. Oregon has very small water diversions compared to the diversions in California. The largest unscreened diversions in Oregon—there are two of them—are each about 1,000 CFS.